SPECIAL TOPIC

Outcomes Article

A Methodological Analysis of the Plastic Surgery Cost-Utility Literature Using Established Guidelines

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Background: Cost-utility studies, common in medicine, are rare within plastic surgery despite their capability of measuring the value of procedures by considering the societal costs of improving quality of life. The objectives of this study were to analyze the design quality of the plastic surgery cost-utility literature and to identify areas of needed improvement for future studies.
Methods: A scoring tool was constructed based on the Recommendations of the Panel on Cost-Effectiveness in Health and Medicine. A PubMed search through October of 2012 was conducted for English-language plastic surgery utility studies. Articles were selected using two inclusion criteria and evaluated using the scoring tool.
Results: A 9-point scoring tool was created, and 37 publications were selected. Their average score was 3 out of 9 points. Thirty studies (81 percent) used population preferences in utility measurements. Fifteen studies (41 percent) measured costs, but only four (11 percent) included indirect costs and only five (14 percent) applied discount rates to calculate the value of treatments over time. Three studies (8 percent) earned zero points. The highest scoring study earned 8 points.
Conclusions: The identified studies manifest the potential of cost-utility analyses in plastic surgery. Nonetheless, they are inconsistent in applying established cost-utility guidelines, especially in measuring costs and conducting recommended sensitivity analysis. Following this simple scoring tool can help future studies achieve some necessary improvements. (*Plast. Reconstr. Surg.* 133: 584e, 2014.)

The last two decades have seen an increasing push to control healthcare spending, and cost-utility analyses have become critical in promoting scientifically based procedure comparisons. This pressure is especially relevant for plastic surgery given that the field is epitomized by novel technique, intervention, and procedure development. However, there is a general lack of familiarity regarding the proper use of health economic evaluations in the plastic surgery literature. The term "cost-effective" is often used to narrowly compare direct costs in plastic surgery, but full economic evaluations, including indirect costs and quality of life, are rare.[1,2] In plastic surgery, only 3 percent of outcomes studies have costs as an endpoint, and only 6 percent of economic evaluations are cost-utility studies.[3] This article aims to address these shortcomings in two ways. First, using a simple scoring tool, this article aims to facilitate a standard design of plastic surgery cost-utility studies as a means to improve their quality. Second, the article identifies the areas that need improvement by scoring the plastic surgery utility literature.

APPLICATION OF HEALTH UTILITY STATES

The central goal of economic evaluations is to demonstrate the "relative value of alternative interventions for improving health."[4] They

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help reduce uncertainty for patients and surgeons by measuring costs and benefits, including quality-of-life impacts.[5] Utility measurements standardize the valuation of health states. The measurements evaluate a patient's ability to function in everyday life in a certain health state. Two forms exist: (1) direct utility measurements and (2) indirect utility measurements. A utility score of 1 represents perfect health and a score of 0 reflects death.

Utility scores are used to calculate quality-adjusted life years in decision-tree analyses. Estimated costs can be divided by quality-adjusted life years to arrive at a dollars per quality-adjusted life year ($/QALY) valuation for each procedure, including costs of extending life and improving quality of life, which is particularly germane to plastic surgery. In comparing dollars per quality-adjusted life year of alternative procedures, we can objectively determine which procedures provide the best value to society and we can make better resource allocation decisions.

Health utility scores are also useful in controversial procedures, where it is unclear whether a procedure's benefits outweigh risks. For example, critics in the medical community wonder whether the risks of non–life-saving composite tissue allotransplantation procedures outweigh their benefits.[6,7] There is a paucity of evidence on the potential psychological, social, and aesthetic benefits of composite tissue allotransplantation (e.g., possessing a "normal" face).[8] The differences in perception between patients living with immunosuppressive drugs and the general population can be resolved with utility measurements, which can offer insights into a condition's impact on a patient's self-perception of quality of life. Utility measurements have already been used in body contouring following massive weight loss, hand transplantation, and other procedures.[9,10] They have been shown to improve patient–physician communication, validate surgical indications, and increase physician understanding of their patients' health-related quality of life.[11–13]

Direct utility measurements include the visual analog scale, time trade-off method, and standard gamble method. On a visual analog scale, patients are asked to rate their current health states on a scale from 0 to 100 (Fig. 1, *above*). The result is converted into a utility value from 0 to 1. The standard gamble method presents an individual with a scenario in which a treatment is capable of returning him or her to perfect health if it succeeds but causes immediate death if it fails (Fig. 1, *center*). The patient's indifference point between success and failure is calculated. Lastly, the time trade-off method calculates the indifference point in sacrificing a percentage of years at the end of life to restore someone to perfect health now (Fig. 1, *below*).

Indirect health utility measurements allow subjects to score health states on multiple functional domains by choosing among a preestablished set of possibilities in each domain. One widely used indirect utility measure is the EuroQol, which measures five dimensions, assigning each three levels of function to generate 243 "vignettes" whose utility scores correlate with disease states (Fig. 2).[14] Others include the Short Form-6 Dimension (SF-6D) and the Health Utilities Index Mark 3 (HUI3).[15]

Although the Panel on Cost-Effectiveness in Health and Medicine (herein referred to as the "Panel") established the standards for conducting thorough cost-utility analysis in 1996, its use in plastic surgery is still in its beginning stages. Recent literature has introduced the basic concepts of cost-utility analysis to the field of plastic surgery.[2,5] However, no study has systematically analyzed the early literature's methodology, as has been done in other fields.[16]

METHODS

Scoring Tool Development

The recommendations set forth by the Panel were used as the standard for the development of the scoring tool.[4,17–19] A simplified checklist was created to assess cost-utility studies across three broad categories: quality-adjusted life year measurements, cost measurements, and sensitivity analyses. All components of the checklist were based on the Panel's recommendations for thorough cost-utility analysis. Criteria in quality-adjusted life year measurements were used to assess whether utilities and the probability of each health state over time were modeled appropriately, using decision trees or Markov modeling. Criteria in cost measurements, meanwhile, were meant to assess whether the way in which costs were measured for each procedure being compared was correct and inclusive of the necessary components. Finally, sensitivity analyses included criteria necessary to assess whether sensitivity analyses of all of the necessary variables were conducted appropriately.

Cost-Utility Literature Search

PubMed was used to search the MEDLINE database for English-language plastic surgery studies using utility measurements in their methods or results. Articles published by October 31, 2012,

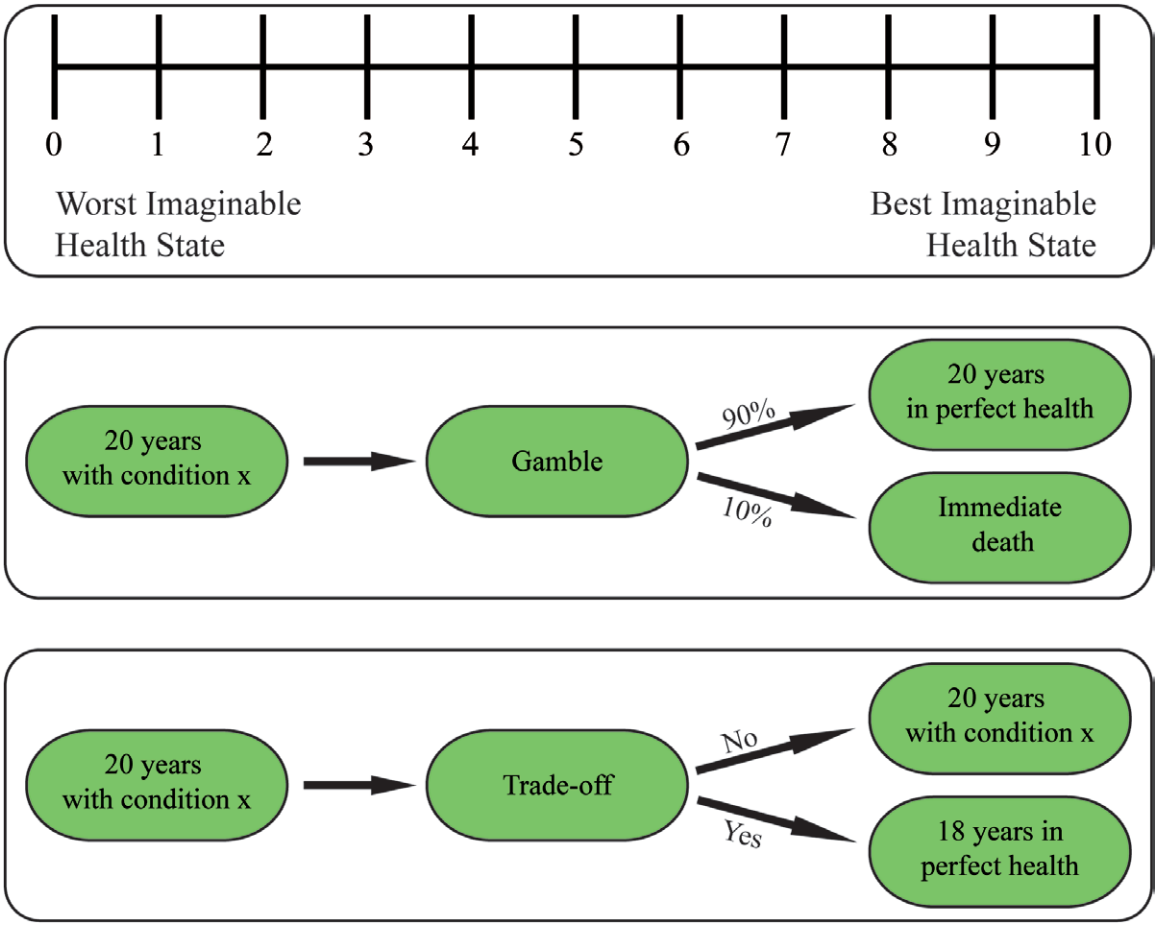

Fig. 1. Direct utility measurements. (*Above*) Example of a visual analog scale thermometer scale used to score a health state. (*Center*) Standard gamble example, showing the starting health state from which one must decide whether or not to gamble. A 10 percent chance of death is depicted. (*Below*) Time trade-off example, representing the starting health state from which one must decide whether or not to trade off remaining life. A 2-year trade-off is depicted.

were considered. The keywords "plastic surgery" were paired with each of the following keywords: "utility," "quality adjusted life year," "QALY," "cost benefit," "value of life," "cost-utility," "quality of life," "standard gamble," "time trade-off," and "visual analog scale." Similarly, the "plastic surgery" Medical Subject Headings term was paired with the following Medical Subject Headings terms: "cost-benefit analysis," "quality adjusted life years," "quality of life," "models, economic," "economics," and "value of life." The plastic surgery Medical Subject Headings term was also combined with the keyword "utility." Article titles and abstracts were screened for mention of utility measurements. Upon further inspection, identified articles needed to meet two inclusion criteria: (1) focus on a topic or procedure relevant to plastic surgery and (2) use utility measurements in their methods or results.

Cost-Utility Literature Scoring

The scoring tool created was used to evaluate the previously identified articles. Each criterion of the scoring tool was worth 1 point and was sought out individually for each article. Scoring (0 to 9 points per article) was done independently by two authors (O.T. and D.M.). The final scores from each author were compared for accuracy, and differing scores were clarified.

RESULTS

We identified nine criteria spanning three categories: two criteria in quality-adjusted life year measurements, four in cost measurements, and three in sensitivity analyses (Table 1).

In total, the cost-utility literature search returned 1636 articles; of these, 37 English-language articles met the inclusion criteria.[6,9,10,20–52] The scoring for each study is presented in Table 2.

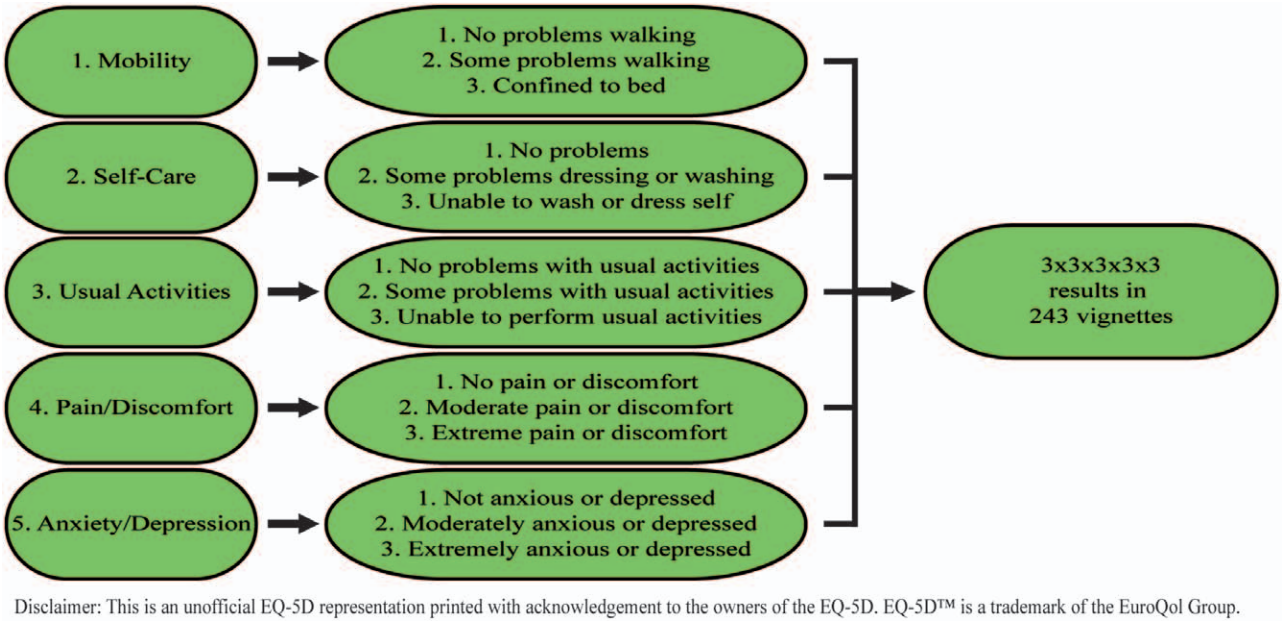

Fig. 2. EuroQol dimensions and scoring. This diagram recreates the basic dimensions used in scoring the EuroQol. Each of the five dimensions is scored by choosing one of its three available levels, and the total score of the five dimensions is then combined for conversion into a corresponding utility score. [Adapted from a EuroQol sample form (The EuroQol Group. Sample UK English EQ-5D-3L. Available at: http://www.euroqol.org/fileadmin/user_upload/Documenten/PDF/Products/Sample_UK__English__EQ-5D-3L.pdf; accessed February 1, 2013).]

The average study score was 3 out of 9 points, with a range of 0 to 8 points (Fig. 3). Overall, 30 studies (81 percent) used direct utility measures and only 14 (38 percent) estimated health state utilities with indirect utility measures. The most frequently used utility measure was time trade-off, with 19 studies (51 percent) using it, whereas 18 studies (49 percent) and 15 studies (41 percent) used the standard gamble and visual analog scale methods, respectively. Within indirect utilities, EuroQol was most popular and used in 10 studies (27 percent).

Table 1. Cost-Utility Study Scoring Tool*

Quality-adjusted life year measurements
1. Population preferences
2. Outcomes modeling
Cost measurements
1. Costs calculations for evaluated procedures
2. Societal costs
3. Inflation adjustments of costs to a reference year
4. Discount rate of 3 percent for costs and health state utilities (in studies that are 1 year or longer)
Sensitivity analyses
1. Discount rate of 0 through 7 percent sensitivity analysis (in studies that are 1 year or longer)
2. Costs sensitivity analysis
3. Quality-adjusted life years sensitivity analysis

*Inclusion of each criterion is worth 1 point. Variables impacting costs and quality-adjusted life years count toward only component #3 within the "Sensitivity Analyses" category.

For quality-adjusted life year measurements, the average category score was 1.2 out of 2 points, with a range of 0 to 2 points per study. For cost measurements, the average score was 1 out of 4 points, with a range of 0 to 4 points per study. Finally, for sensitivity analyses, the average score was 0.8 out of 3 points, with a range of 0 to 2 points per study. The percentage of studies that met each of the nine criteria is presented in Table 3.

Outside of the requirements made by the Panel, other interesting trends were observed. We found that 16 studies (43 percent) used patient preferences to derive health state utilities, 14 (38 percent) used multiple utility measures to estimate the utility of each health state, and 10 (27 percent) used patient preferences and population preferences in the scoring of health state utilities to observe for possible differences between them. Seven studies (19 percent) also measured health state utilities prospectively over time. Only two studies (5 percent) reported the use of an interviewer.

DISCUSSION

To our knowledge, this is the first published systematic review and analysis of the plastic surgery cost-utility literature methodology. The 37 studies we identified were pioneers in introducing the concept of utility theory in plastic surgery.

Table 2. Point Summary, by Study

No.	First Author	Year	Journal	QALY Measurements	Cost Measurements	Sensitivity Analyses	Total Points
1	Chung	1998	*PRS*	1	0	0	1
2	Klassen	1999	*JECH*	1	0	0	1
3	Kerrigan	2000	*PRS*	2	3	1	6
4	Chang	2001	*PRS*	2	0	1	3
5	Kerrigan	2001	*PRS*	1	0	0	1
6	Thoma	2003	*Microsurgery*	2	2	2	6
7	Thoma	2004	*PRS*	2	0	1	3
8	Barker	2006	*PRS*	2	3	1	6
9	Brouha	2006	*Microsurgery*	2	2	2	6
10	Davis	2006	*PRS*	2	1	2	5
11	Majzoub	2006	*JHS*	2	0	1	3
12	Thoma	2006	*Can J Plast Surg*	2	4	2	8
13	Cugno	2007	*Can J Plast Surg*	1	0	0	1
14	Thoma	2007	*PRS*	1	0	0	1
15	Cavaliere	2008	*JHS*	0	0	0	0
16	Preminger	2008	*PRS*	1	0	0	1
17	Saariniemi	2008	*JPRAS*	1	3	2	6
18	Thoma	2008	*Can J Plast Surg*	1	1	1	3
19	Vasilic	2008	*PRS*	1	0	0	1
20	Chung	2009	*PRS*	0	3	2	5
21	Ram	2009	*JHS*	0	0	0	0
22	Cavaliere	2010	*JHS*	1	0	0	1
23	Chung	2010	*PRS*	1	0	0	1
24	Peyasantiwong	2010	*Curr HIV Res*	1	0	0	1
25	Sinno	2010	*PRS*	1	0	0	1
26	Tykka	2010	*JPRAS*	1	0	0	1
27	Chen	2011	*JHS*	1	0	0	1
28	Chung	2011	*Ann Plast Surg*	1	0	0	1
29	Sinno	2011	*Aesth Plast Surg*	2	4	1	7
30	Yeung	2011	*Ann Plast Surg*	2	2	2	6
31	Saariniemi	2012	*JPRAS*	0	0	0	0
32	Sinno	2012	*Ann Plast Surg*	2	2	2	6
33	Sinno	2012	*Ann Plast Surg*	2	2	2	6
34	Sinno	2012	*PRS*	2	2	2	6
35	Sinno	2012	*The Breast*	0	2	2	4
36	Sinno	2012	*OHNS*	1	0	0	1
37	Song	2012	*JHS*	1	0	0	1
			Total points	46	36	29	111
			% of total	62	24	26	33

QALY, quality-adjusted life year; *PRS, Plastic and Reconstructive Surgery; JECH, Journal of Epidemiology and Community Health; JHS, Journal of Hand Surgery; Can J Plast Surg, Canadian Journal of Hand Plastic Surgery; Curr HIV Res, Current HIV Research; JPRAS, Journal of Plastic, Reconstructive & Aesthetic Surgery; Ann Plast Surg, Annals of Plastic Surgery; Aesth Plast Surg, Aesthetic Plastic Surgery; OHNS, Otolaryngology Head and Neck Surgery.*

Their important contributions provide early perspectives of the possibilities, yet there is still room for improvement. The scoring tool, by covering the main criteria of a standard cost-utility study, was useful in identifying areas for improvement. However, the scoring tool is not meant to suggest that a score of 6 is twice as a good as a score of 3, but simply that the study followed more of the guidelines established by the Panel. Just as an article with a level of evidence of II is not necessarily half as good as a level I evidence article, the goal of the scoring tool is to facilitate the inclusion of guidelines, just as one would strive for a higher level of evidence manuscript whenever possible. Overall, there is room for improvement across the three required criteria categories, particularly within cost measurements and sensitivity analyses. However, some studies have also attempted to make cost-utility data more rigorous by going beyond the standards set by the Panel.

In the quality-adjusted life year measurements category, population preferences were most consistently applied. As the standard perspective, it is critical for all studies to use population preferences to calculate health state utilities because it allows a common comparison among studies. However, outcomes modeling with decision trees or more sophisticated models, to predict the effect on quality-adjusted life years that a procedure has throughout a patient's lifetime, was used in only 16 studies. For further instruction on how to build decision tree models, please refer to Kotsis and Chung.[5]

For the cost measurements category, fewer than half of the studies took the final step of completing a cost-utility analysis by including costs instead of just utilities. Moreover, among those

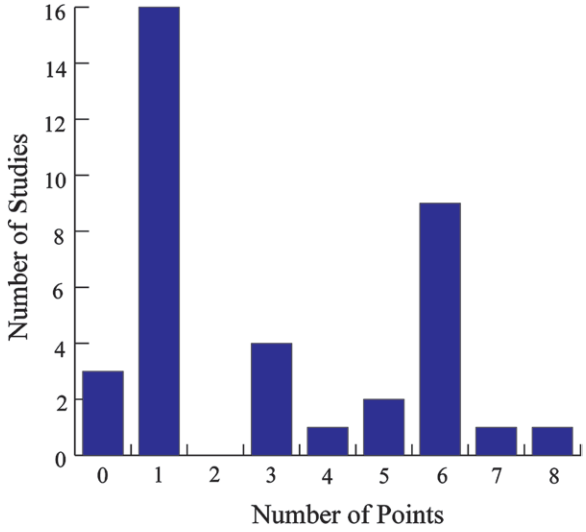

Fig. 3. Histogram of studies' total scores.

Table 3. Number of Studies That Met Each Requirement

Criterion	No. (%)
Quality-adjusted life year measurements	
Population preferences	30 (81)
Outcomes modeling	16 (43)
Cost measurements	
Cost calculations	15 (41)
Inflation adjustment	12 (32)
Discount rate adjustment	5 (14)
Societal costs calculations	4 (11)
Sensitivity analyses	
Quality-adjusted life year sensitivity analysis	18 (49)
Cost sensitivity analysis	11 (30)
Discount rate sensitivity analysis	0 (0)

that did, fewer than one third took on the societal perspective of costs recommended by the Panel, including indirect costs, such as patient's time, costs to employers, and other costs that the procedure can have on society. Most of the studies simply measured the direct costs of the procedures. Table 4 shows a quick review of what costs should be included in societal costs. Most of the studies that included costs did adjust for inflation, but only a third of the studies measuring costs applied the standard 3 percent discount rate recommended by the Panel. The discount rate is what allows us to measure the changing value of money over time and takes into account the uncertainty of future money. Discounting is a necessary component for calculating the present value of costs spent throughout a patient's lifetime. It is equally important to apply the discount rate to health state utilities over time, for a year of life now is worth more to patients than an uncertain year of life in the future. For a more detailed discussion

Table 4. Recommendations on Societal Costs and Length of Time Measurements

Types of societal costs
Costs of patient time
Costs of care-giving (both paid and unpaid)
Costs associated with illness (travel expenses, childcare)
Costs to employers, employees, and the rest of society ("friction costs" related to absenteeism and employee turnover)
Costs associated with the intervention's nonhealth impacts (on the educational system, criminal system, and the environment)
Length of time
Costs of related diseases in the original life span
Costs for intervention-related diseases that occur in added years of life
Costs of an ongoing therapy throughout added years of life

of the discount rate, please refer to the Panel's recommendations.[18]

In the sensitivity analyses category, it is not surprising that the criterion with the most room for improvement is the discount rate sensitivity analysis. While some studies did carry out a narrow sensitivity analysis, the recommendation to include a sensitivity analysis from 0 to 7 percent was never met. All cost-utility studies should present final calculations of the dollars per quality-adjusted life year of each procedure, which is the value used to compare alternative treatment options. The final calculation of dollars per quality-adjusted life year is influenced by the way quality-adjusted life years and costs are calculated and the discount rate that is applied to both. For this reason, it is crucial to measure the impact of varying all three variables to determine how rigorous the results are in the face of change. The more consistent they are throughout the sensitivity analyses, the more likely they are to be true. Many more studies have conducted a sensitivity analysis of quality-adjusted life years or costs, but even those were not done by all studies, and should be done in all instances.

Although there is room for improvement in all categories, some trends observed outside of the Panel's recommendations may be particularly useful in plastic surgery. Given the individuality of assessing one's health state for many plastic surgery conditions, the use of direct utility measures by some studies allowed them to capture people's valuation of health states by not limiting them to the predetermined functional domains of indirect utility measures. Similarly, patient preferences were not recommended by the Panel, but in the field of plastic surgery, where patients' perceptions of their own health state are very individualistic and may be different from the general

population's perspective, we believe including them adds value to the study. We also believe that, as some studies did, it is beneficial to include multiple utility measures, especially direct and indirect utility measures, given the slight variations in health state utility estimates that each produces. Doing so improves the study's rigor and improves comparability across studies. Moreover, there are still some valid concerns regarding direct utility measures, which is less of a concern if studies use multiple utility measures.[53–55] Finally, another component of some studies was the prospective measurement of health state utilities over time, which could add to the accuracy of the data, as prior research suggests patients' perceptions change over time.[56]

Cost-utility studies are not a panacea for difficult decisions and should be placed in the context of broader society's concerns when used to make resource allocation and health policy decisions. One limitation of our study is that the scoring is based on what is reported in the articles, yet some studies may have met more guidelines than they received credit for. The reporting guidelines proposed by the Panel should be referenced for a detailed review of what to include.[19] Another limitation of our study is that not all of these studies attempted to compare procedures, instead simply using utility theory to compare health states or estimate quality of life. However, given the limited number of studies in plastic surgery, we decided to include these in our list and score them normally, to measure how many more components they needed to fully implement the recommendations of the Panel. Ultimately, we believe that only by implementing all of the Panel's recommendations will studies be able to maximize their impact on the field of plastic surgery. One additional limitation is the inconsistent ways in which costs are both measured and reported. The term "cost" is used interchangeably with charges, resource use, reimbursement, and other terms, and is not distinguished by the scoring tool. The Panel recommends trying to estimate the actual cost of resources used, meaning what a hospital charges is not necessarily the same as the amount of resources it actually used. However, estimating true costs is difficult, and is sometimes best approximated by charges, reimbursement, or other dollar values. For detailed reading on this topic, we suggest referring to the Panel's original recommendations.

In increasingly cost-conscious hospitals and societies, including the changing U.S. health-care economic climate, measuring the value of plastic surgery interventions will become more critical, especially as the government tries to insure as many people as possible through the Affordable Care Act. Rigorous cost-utility studies based on the Panel's guidelines present the best way to collect data on the value of plastic surgery interventions.

CONCLUSIONS

Quantifying health states through utility measurements can help elucidate some of the controversies present within plastic surgery. To our knowledge, this is the first attempt to systematically assess the plastic surgery cost-utility literature using a scoring tool based on the Panel on Cost Effectiveness in Health and Medicine. As the scoring tool makes clear, there are opportunities for improvement, especially with respect to inclusion of indirect societal costs and application of discount rates. We believe that following this simple scoring tool can help studies better implement the Panel's recommendations, carry more weight, and provide more useful data to help physicians, patients, and society better understand the benefits and limitations of what plastic surgery can deliver. A scientific foundation to evaluate various interventions can ultimately pave the way toward more holistic patient care. The results and benefits of cost-utility studies are worth the effort.

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